Computational modelling of person-environment transactions

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Genetic influences

- From twin data:
  - Pervasive across breadth and flavour of traits
  - About 50% of phenotypic variance heritable
- From family and adoption data:
  - Estimates somewhat weaker
- From molecular genetic data (GCTA)
  - Estimates yet weaker

Why?

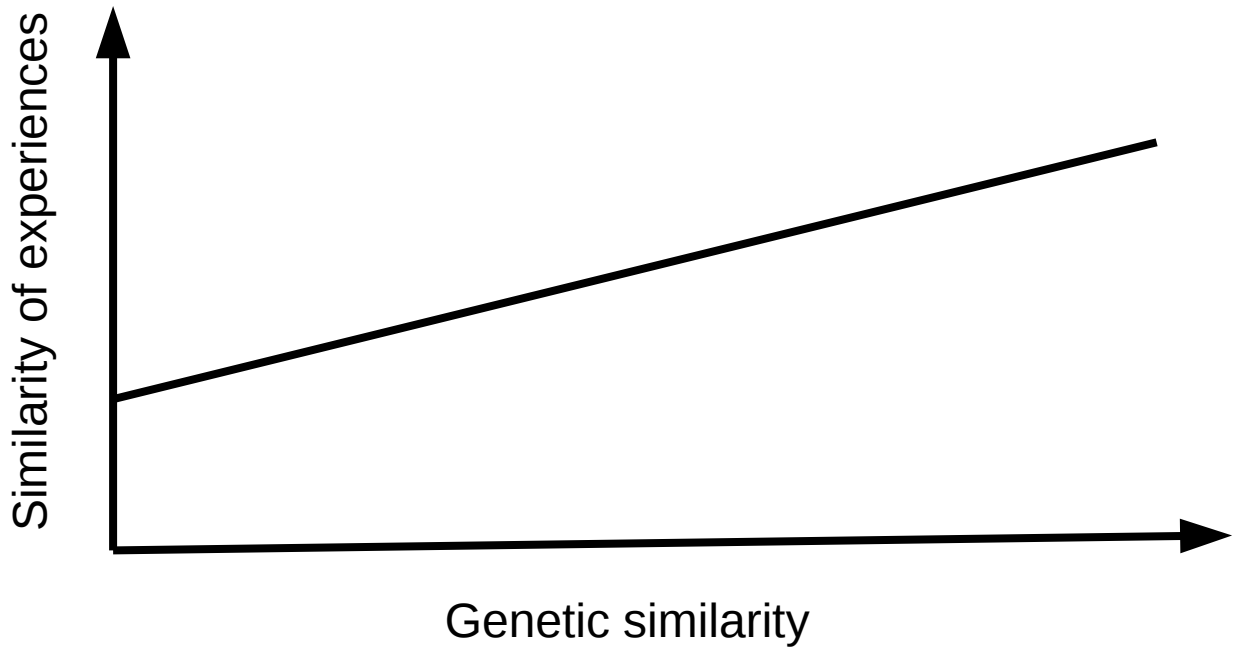
- Traits highly polygenic
  - Zillion polymorphisms, each with a minor effect
- Rare variants
- Missing heritability

- Additive heritability estimates inflated
  - Person-environment transactions (PET)
  - Pervasive personality influences on life choices
  - Positive feedback loops make genetically similar people phenotypically yet more similar

- Genetic variance 'non-additive'
  - Phenotypic similarity increases exponentially with genetic similarity
  - Small genetic differences can lead to relatively larger phenotypic differences
  - Family/adoption studies and GCTA address only additive variance

- I will address both simultaneously
  - PET and non-additive variance

- Does PET contribute to additive influence?
  - Genetic similarity linearly related to environmental similarity
  - No idea
  - Why think otherwise if we consider only one trait at a time?

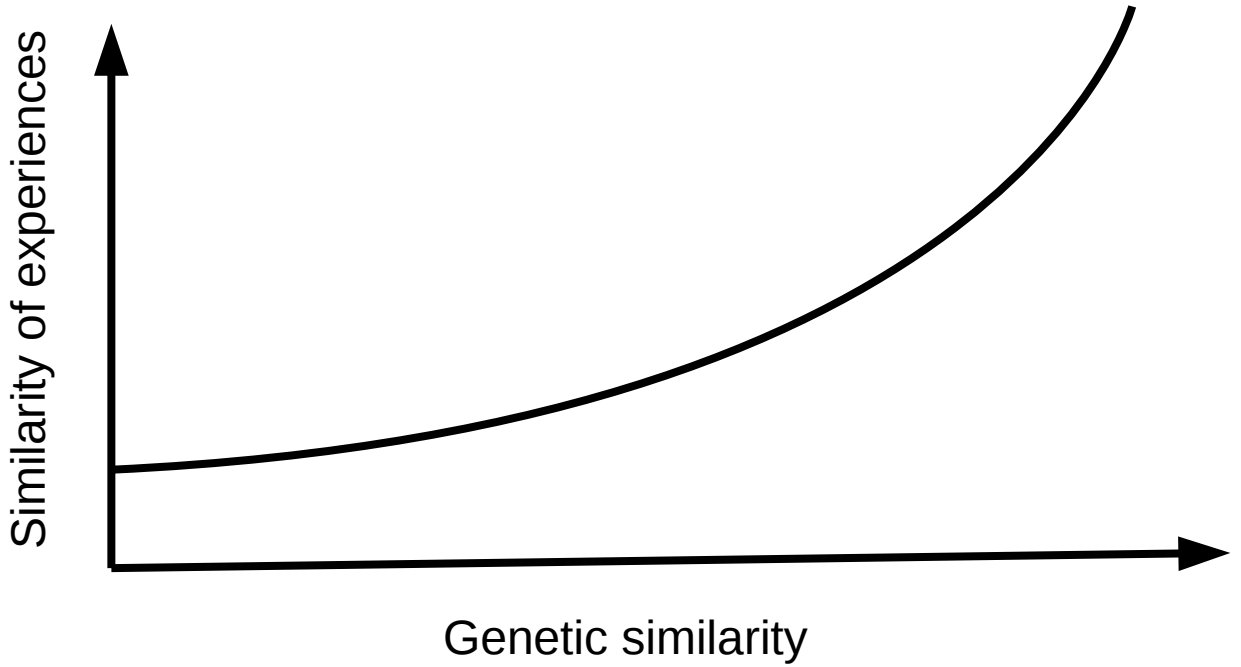


Multi-trait perspective

- Perhaps people do not transact with environments based on all characteristics
  - Salient (central, most expressed) traits for niche-picking

Caspi & Moffitt, 1993

- Genetic differences increase the likelihood of different characteristics being salient
  - Even small genetic difference may lead to very different environments
  - Results in increasing phenotypic differences



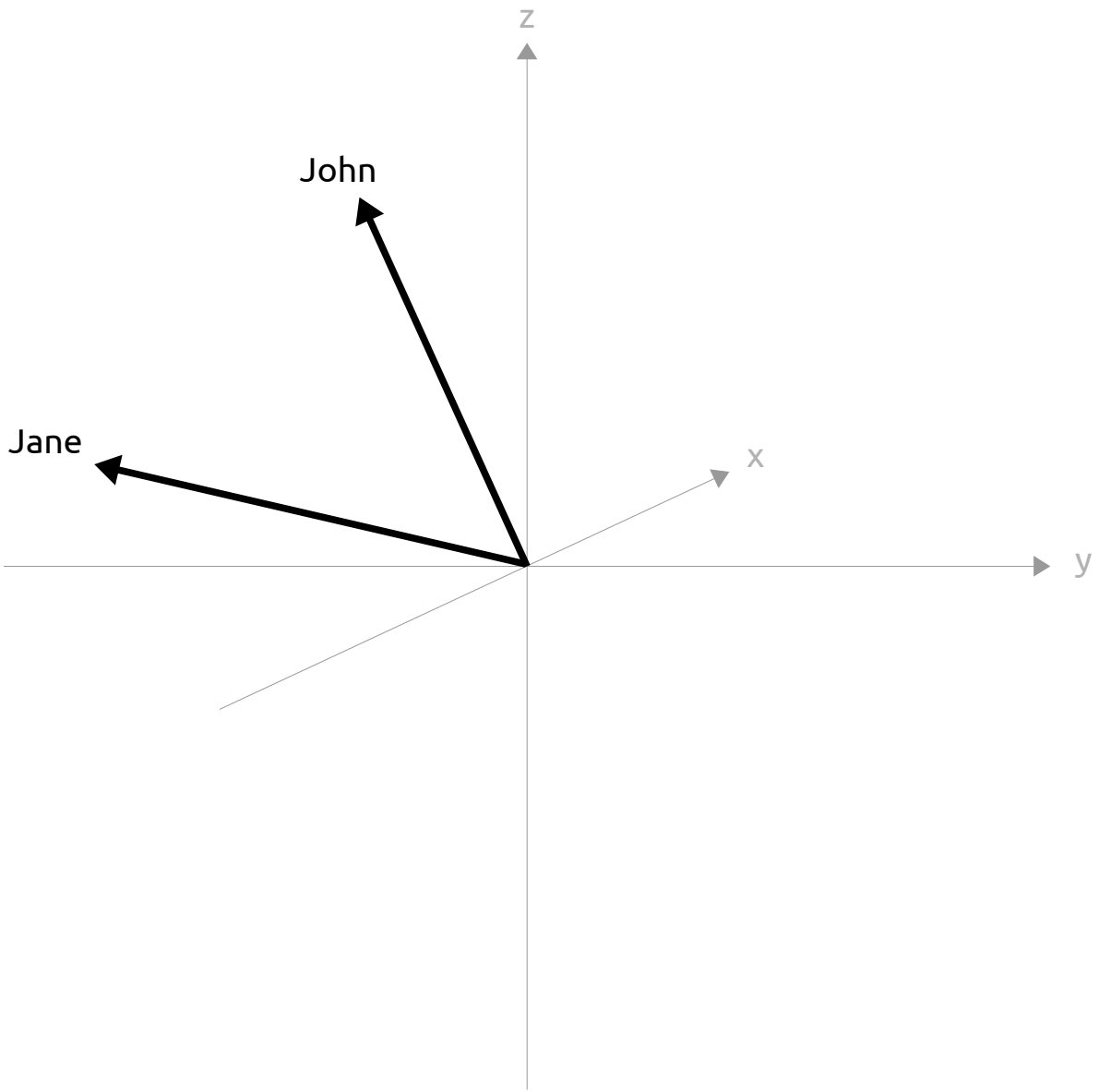
Hypothesis

- Non-additive variance is (also) PET in disguise
  - Especially when PET are based on limited traits

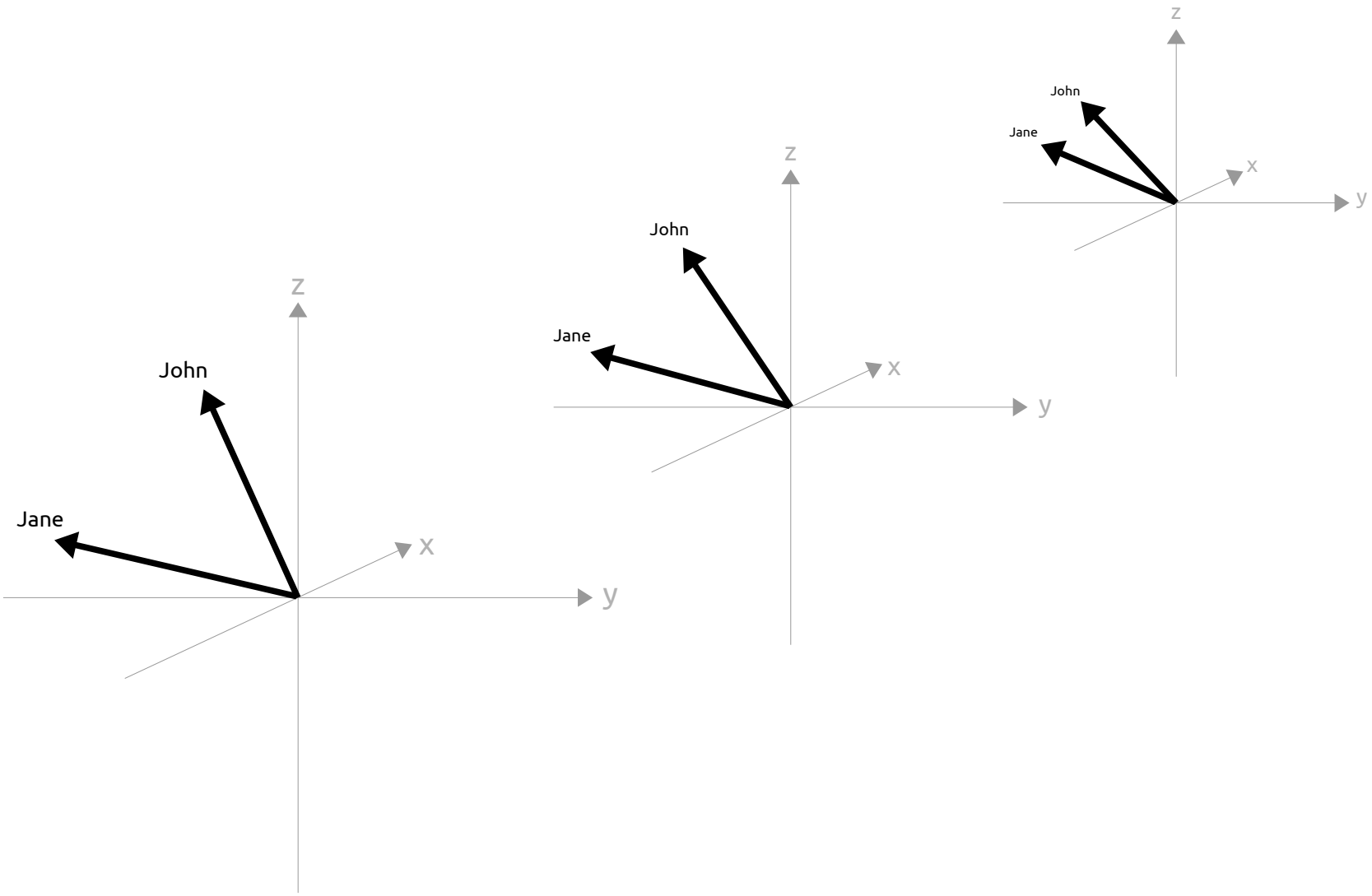
Different scenarios of a computational model

- PET absent *vs* PET present
- PET based on varying proportions of traits
- Expectation:
  - Smaller proportions yield more 'non-additive' variance

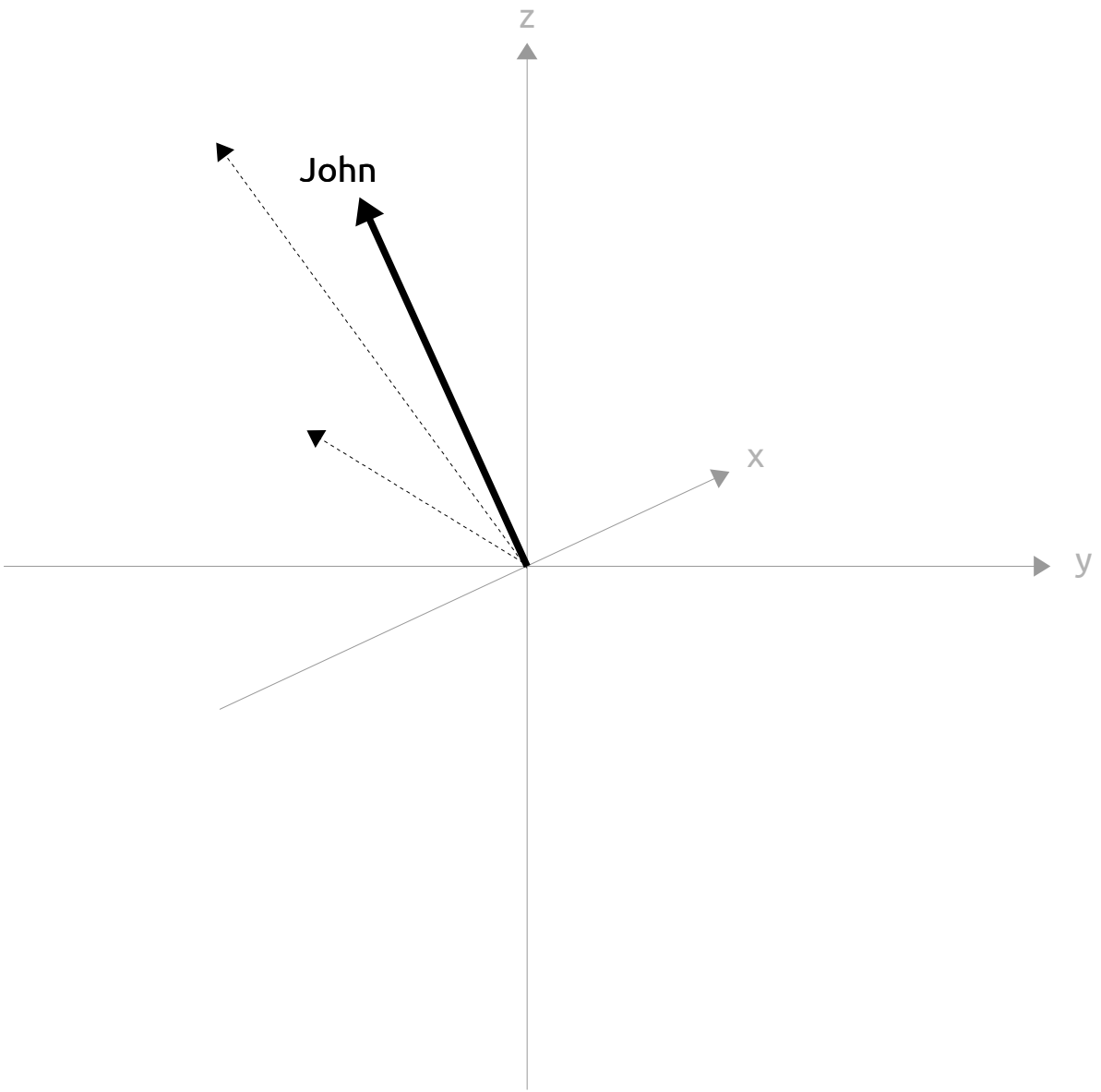
Computational model framework



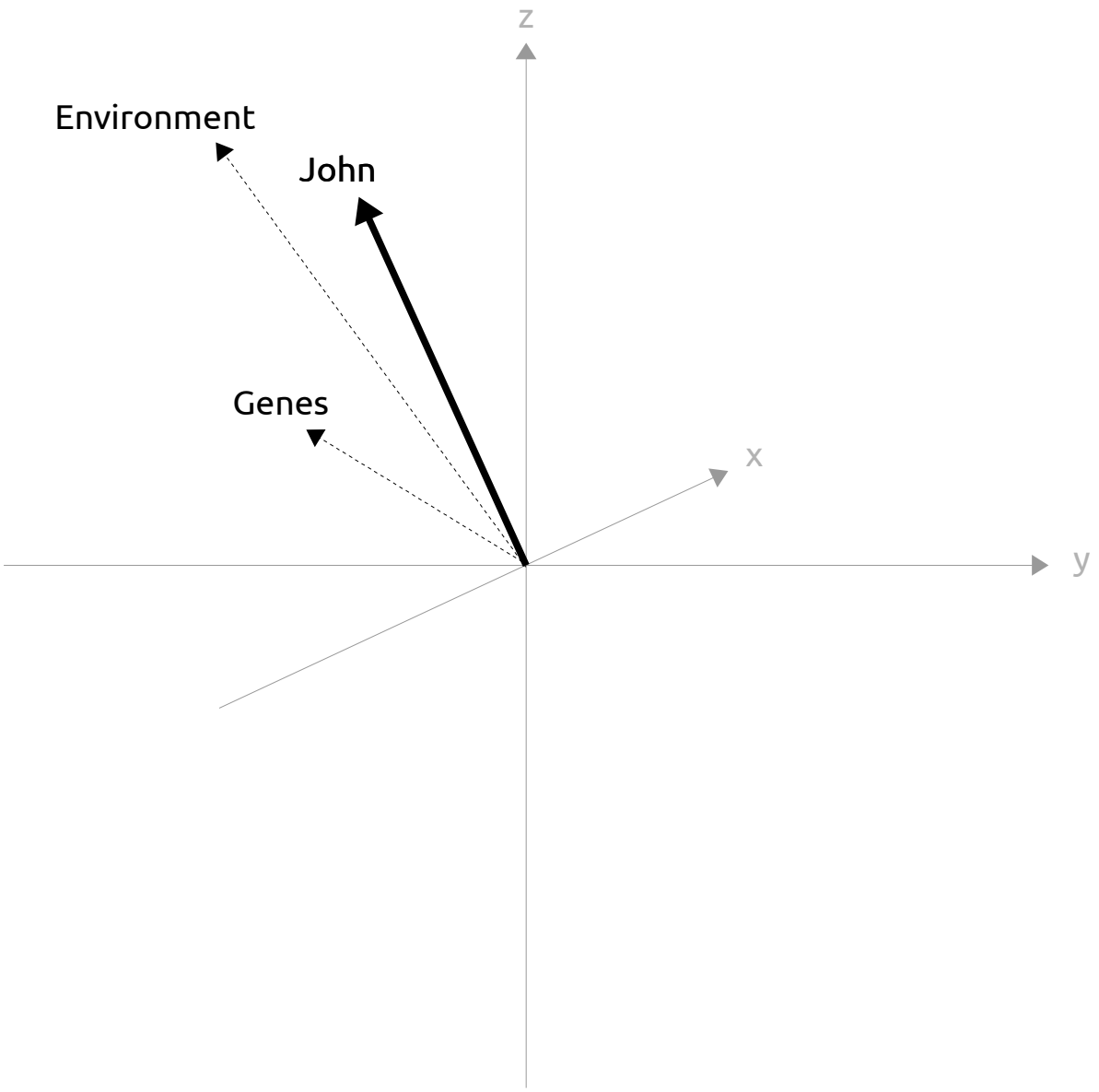
The feature space may have a zillion dimensions



Development through discrete cycles



The feature space is also a force field



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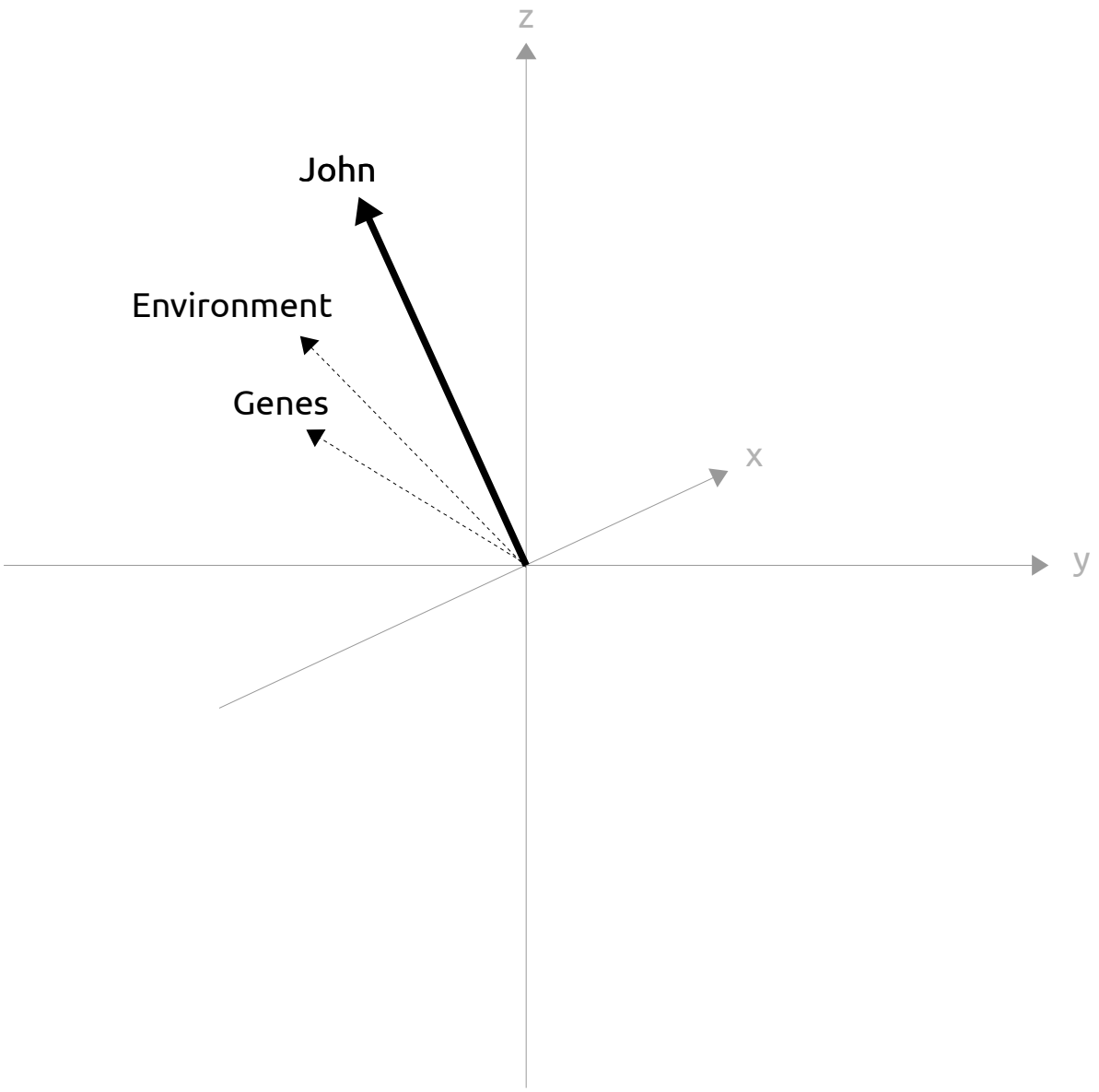

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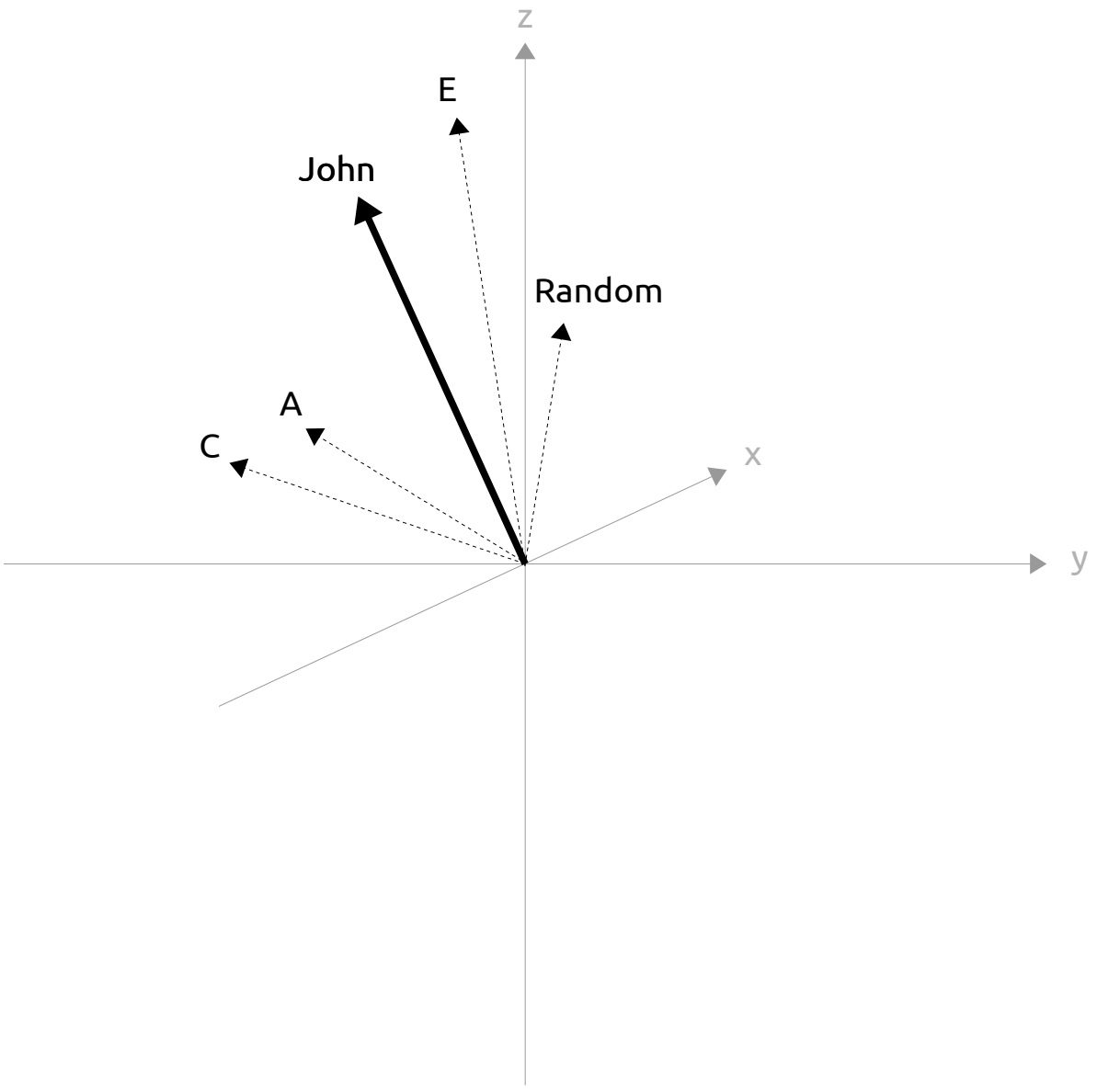
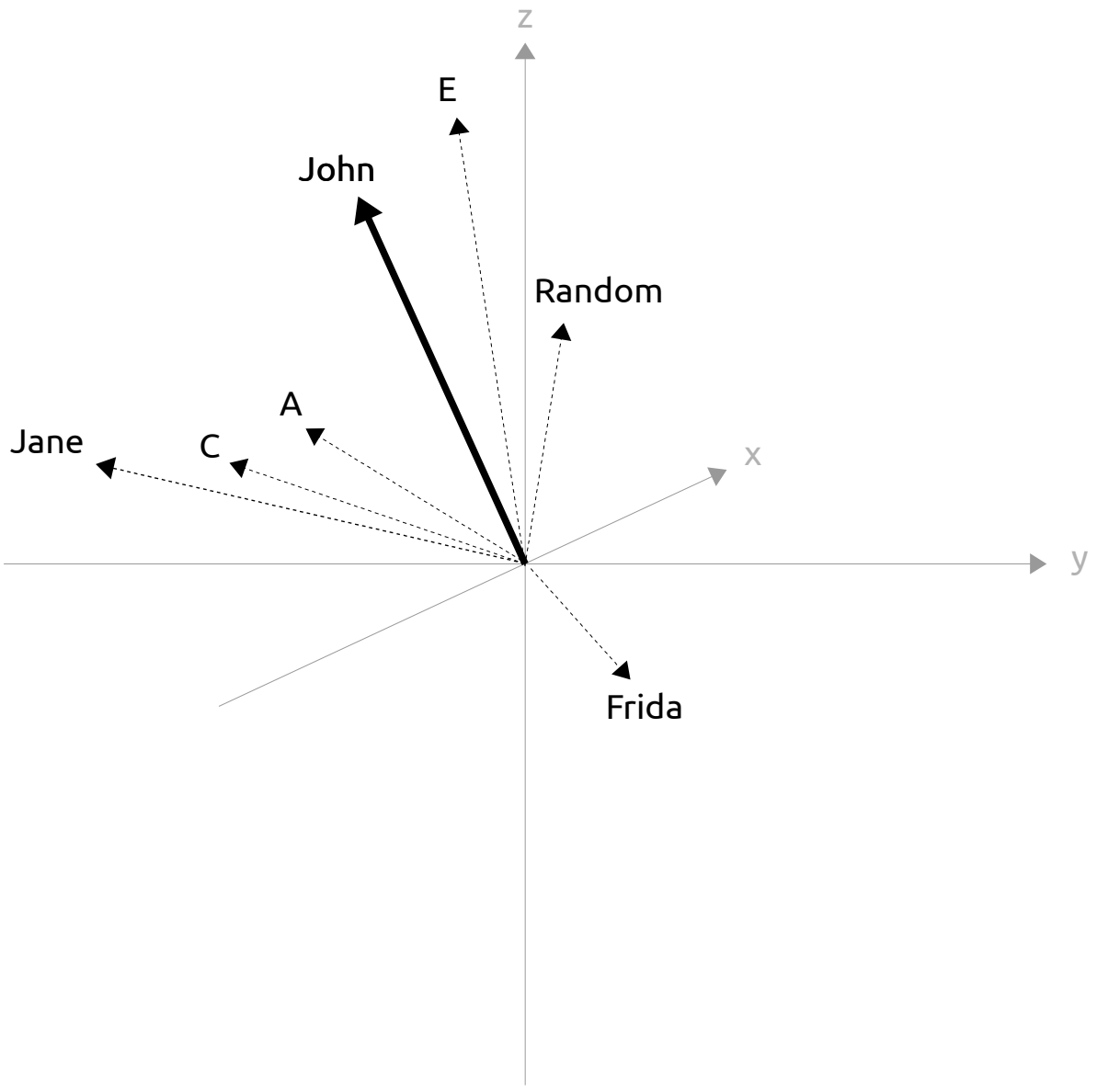

z
E
John
Random
A
C
x
y


z
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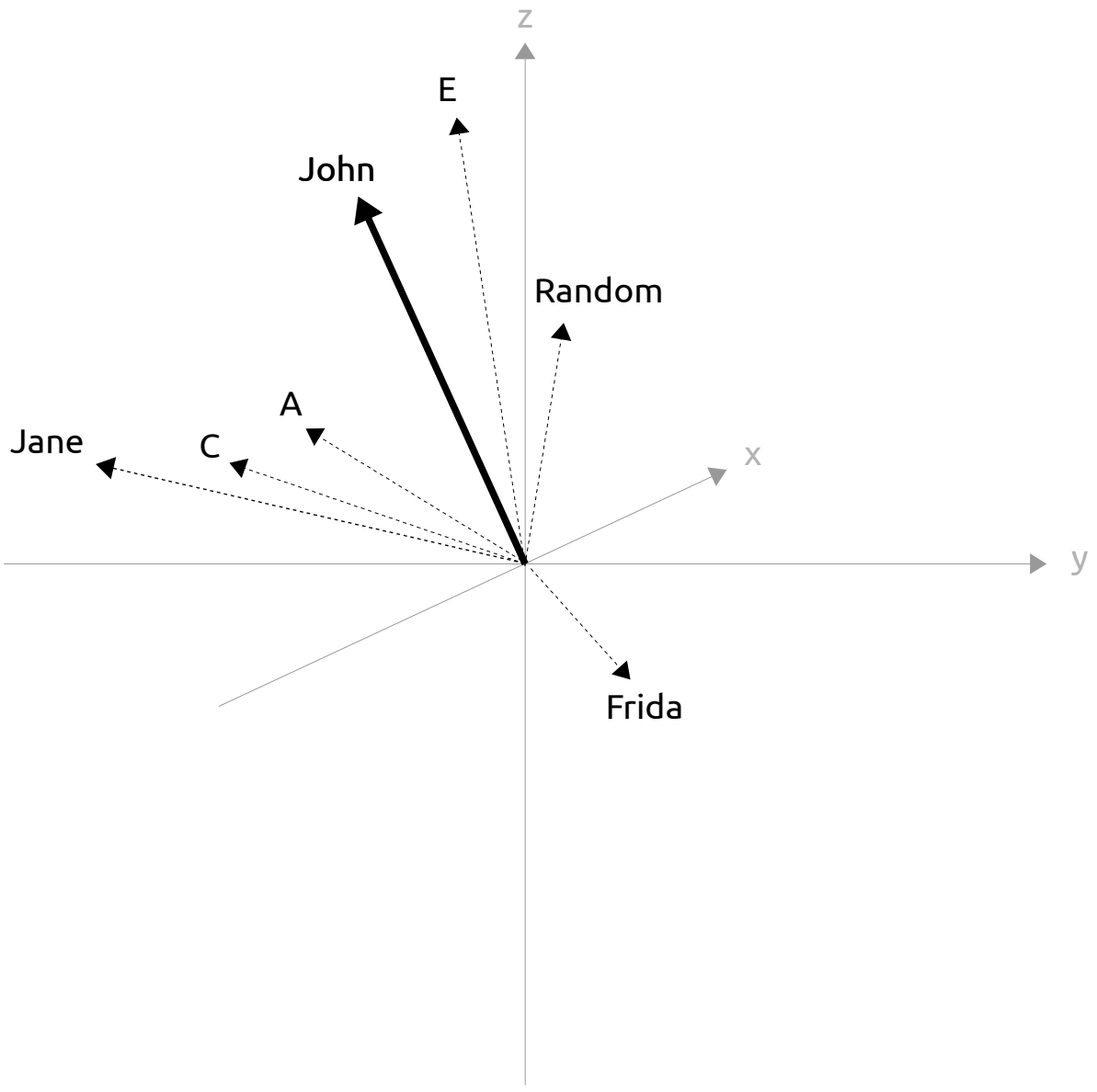
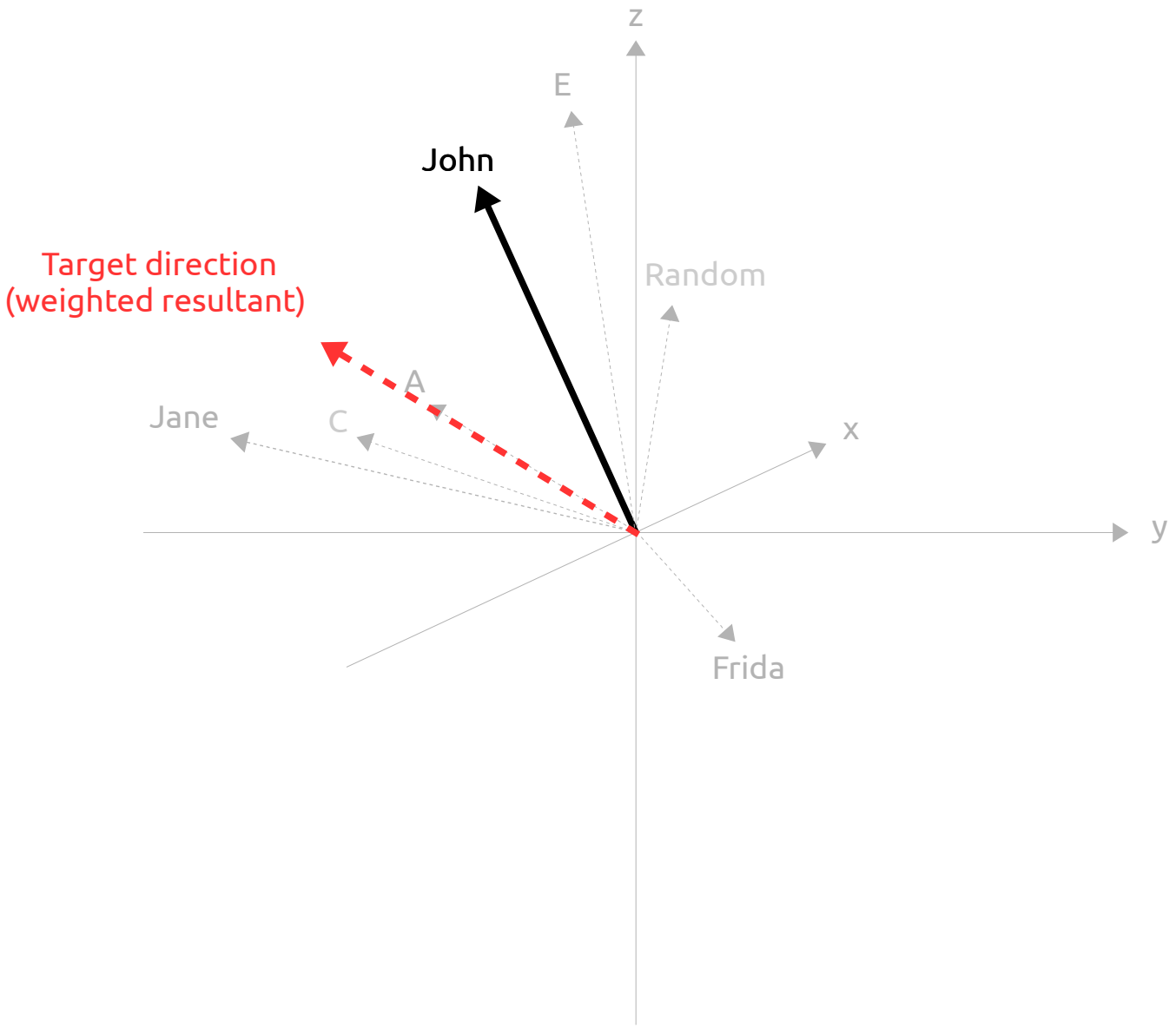


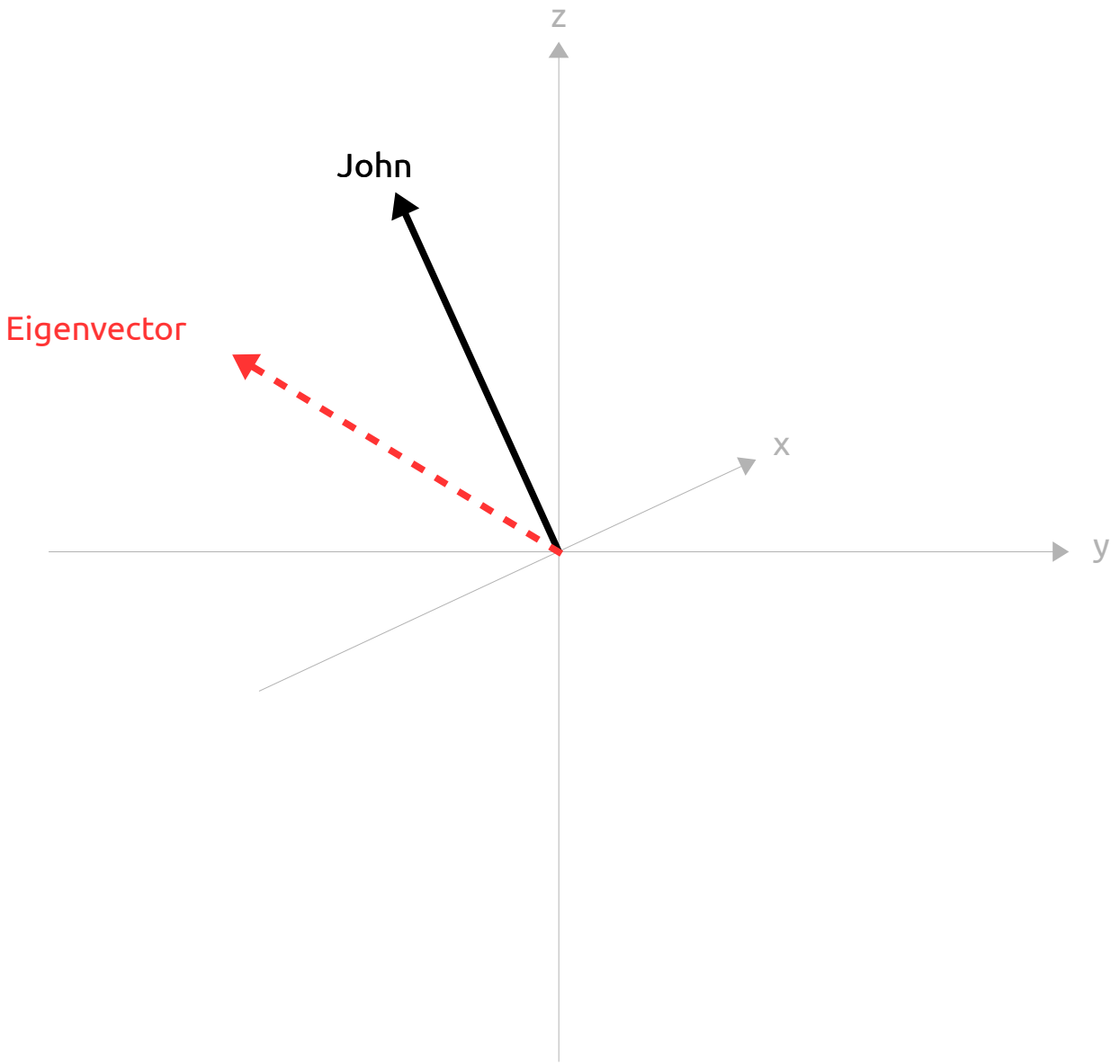
Different forces can have different weights



At every cycle, John is attracted to the target direction

Updating an individuals location
(at any one cycle)

new scores = weight matrix * previous scores



Target direction is the eigenvector of the weight matrix

Step 1 Translate target direction to weight matrix

$$\begin{pmatrix} -.50 \\ -.50 \\ .00 \end{pmatrix} \Rightarrow \text{Oblique projection} \Rightarrow \begin{pmatrix} -.26 & -.29 & .00 \\ -.22 & -.24 & .00 \\ .00 & .00 & -.50 \end{pmatrix}$$

Step 2 Project person vector towards target direction

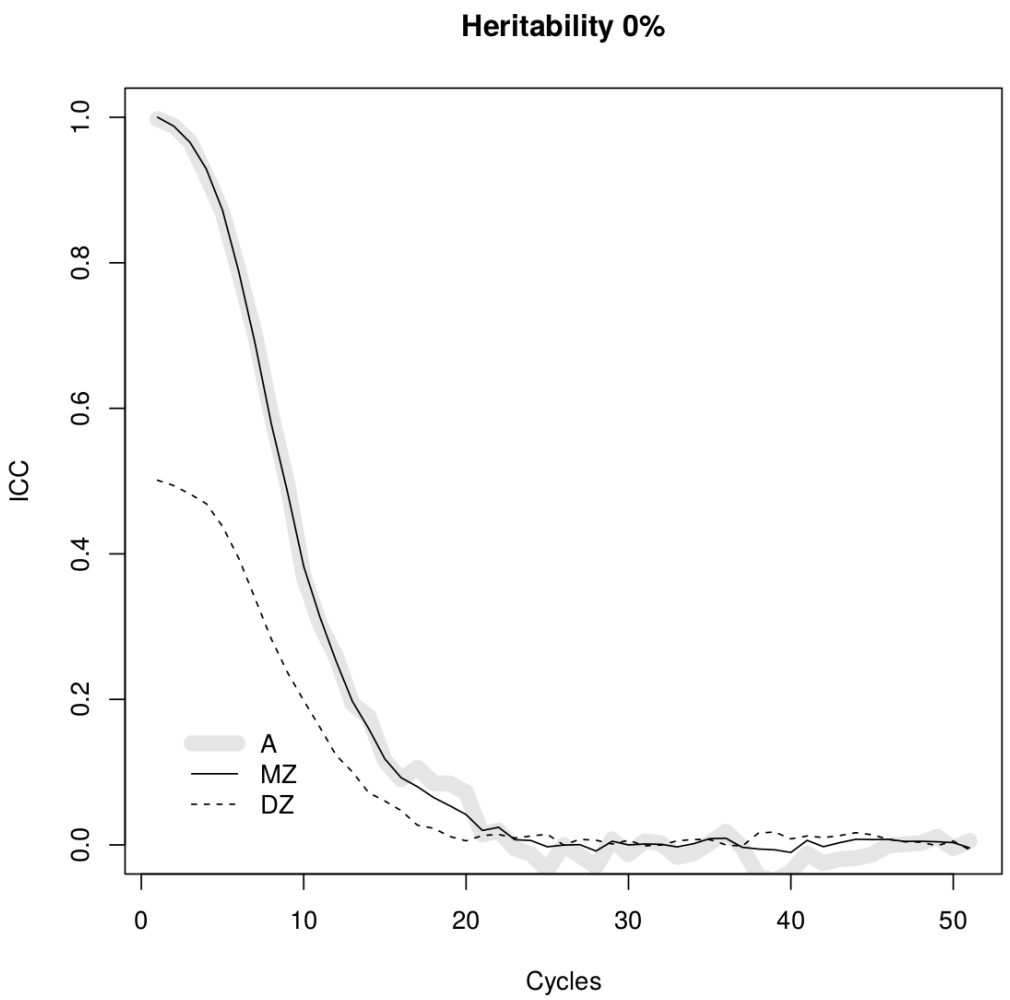
$$\begin{pmatrix} -.26 & -.29 & .00 \\ -.22 & -.24 & .00 \\ .00 & .00 & -.50 \end{pmatrix} * \begin{pmatrix} -.50 \\ -.50 \\ 1.00 \end{pmatrix}$$

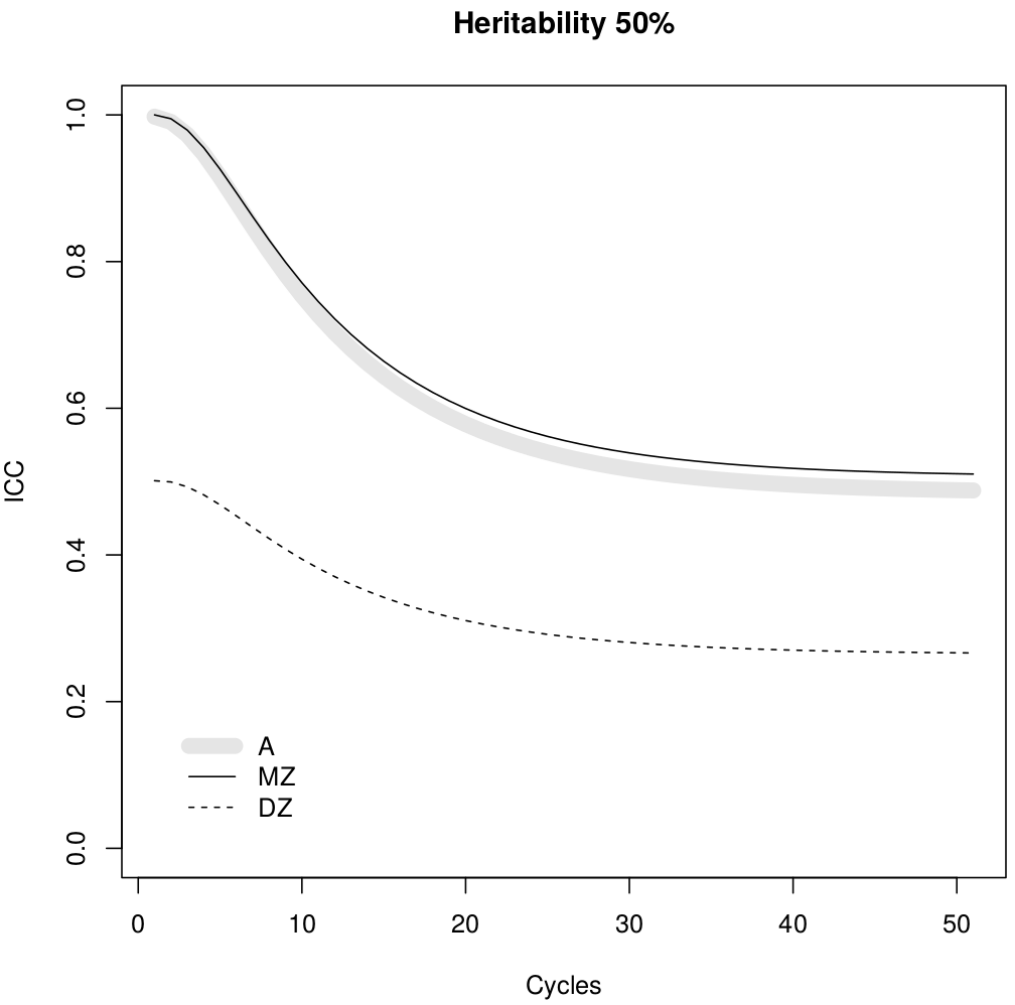
PET ~ social interactions

- Individuals tend to become like 'friends'
- Similar individuals more likely to interact
  - Direct selection, picking similar niches (“social homogamy”)
- Individuals become parts of their own environment
- Initially similar become more similar
  - By reinforcing their own and 'friends' traits

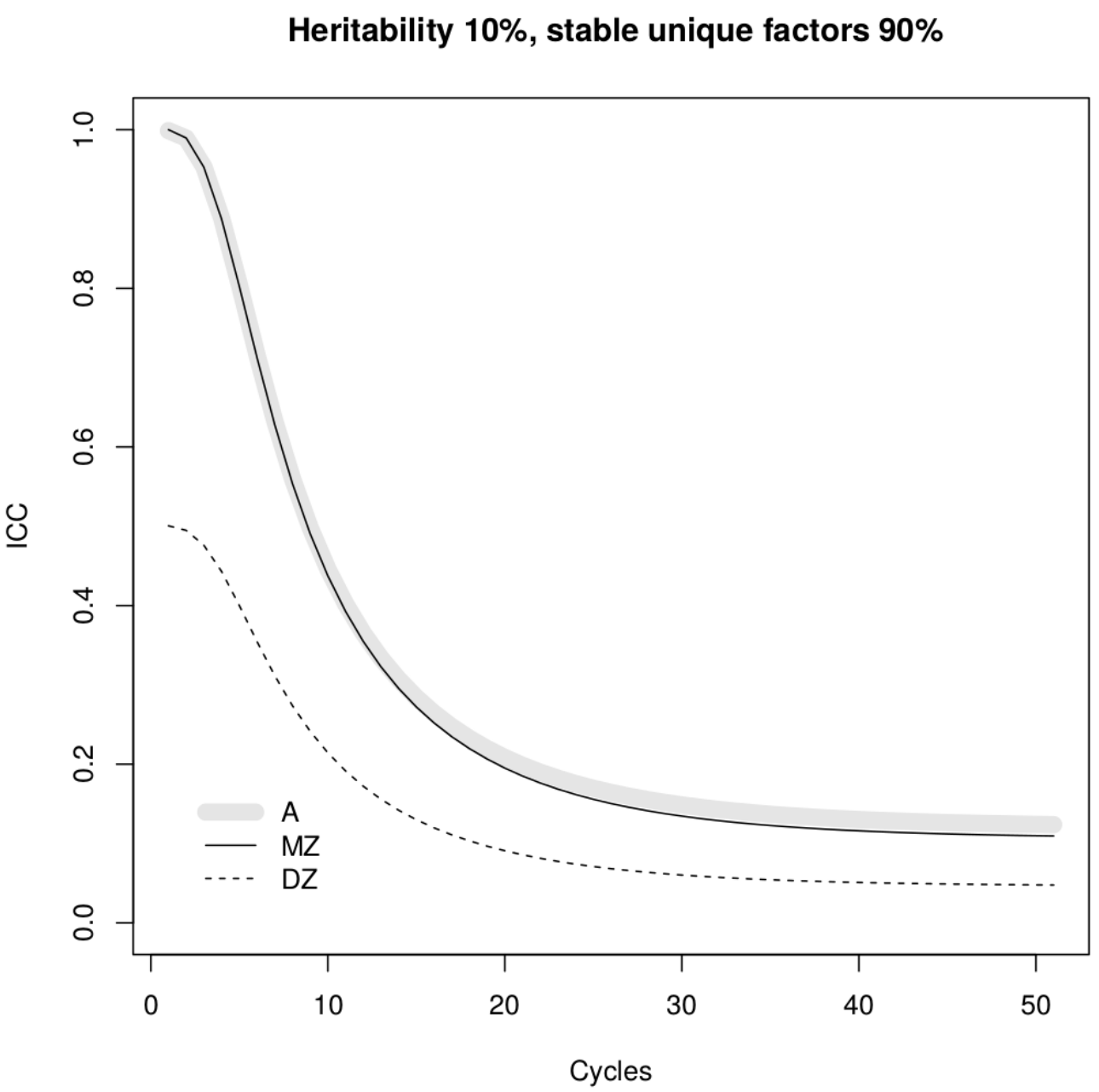
- 50 traits develop through 50 cycles
- Twin structure: 500 'twin pairs'
  - 250 genetically identical, 250 half-identical
- Initial trait levels 100% genetic
  - Oversimplification
  - But heritability is very high in childhood
  - Kept constant in all scenarios

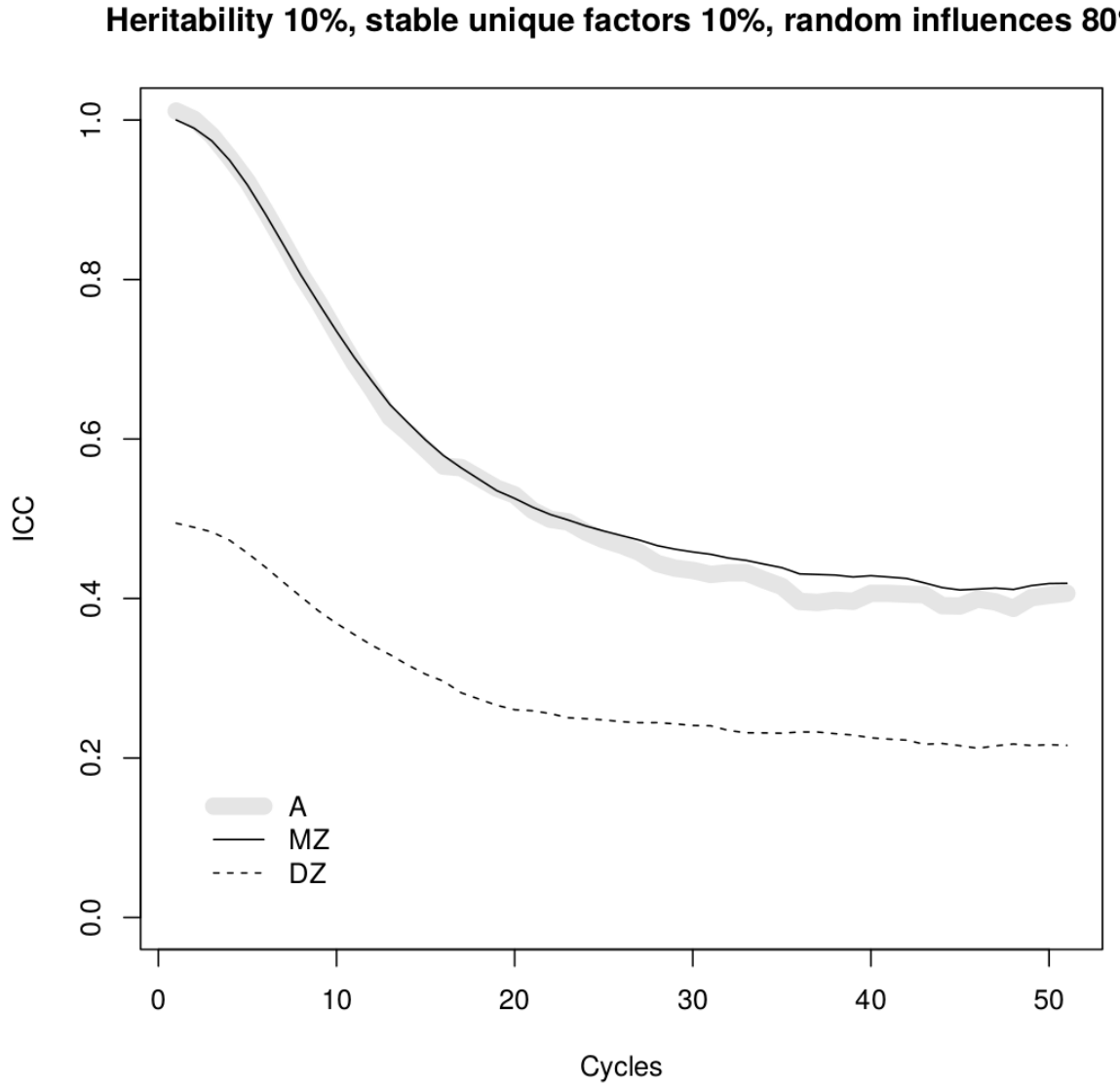
Sanity check: no social interactions





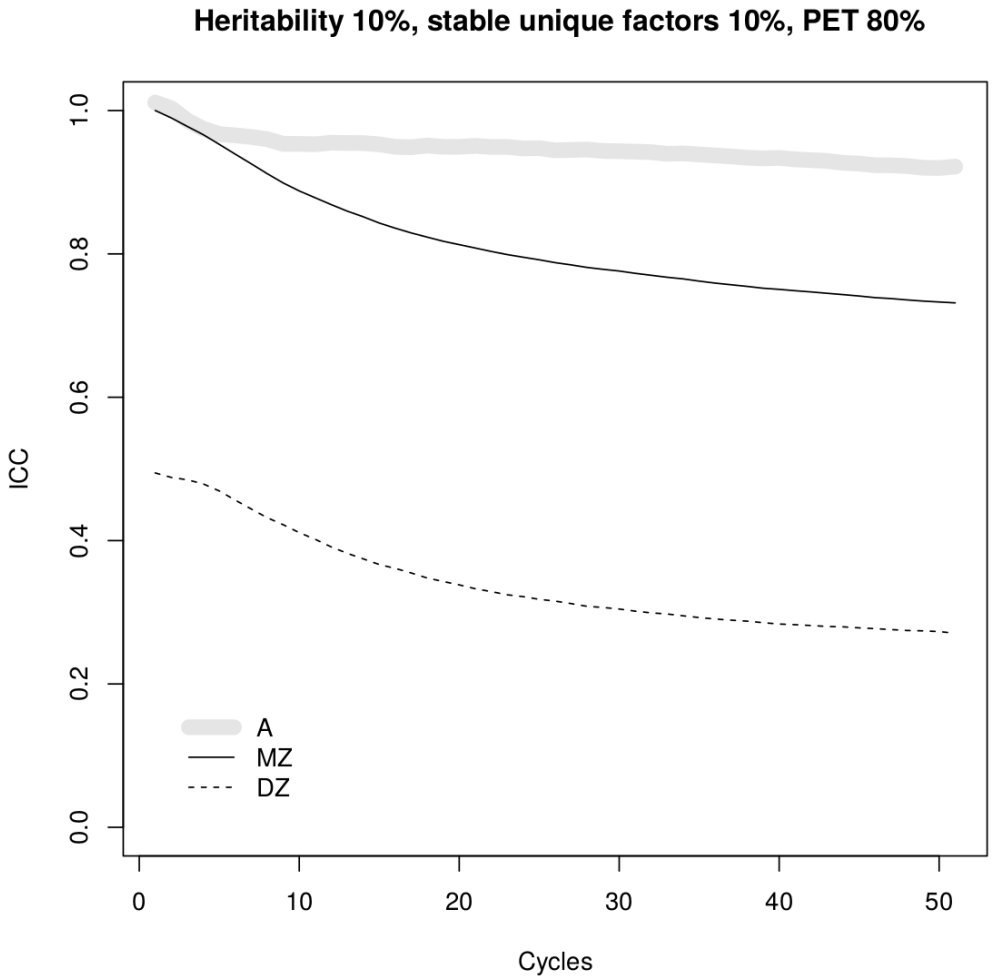
Average estimates across the 50 traits

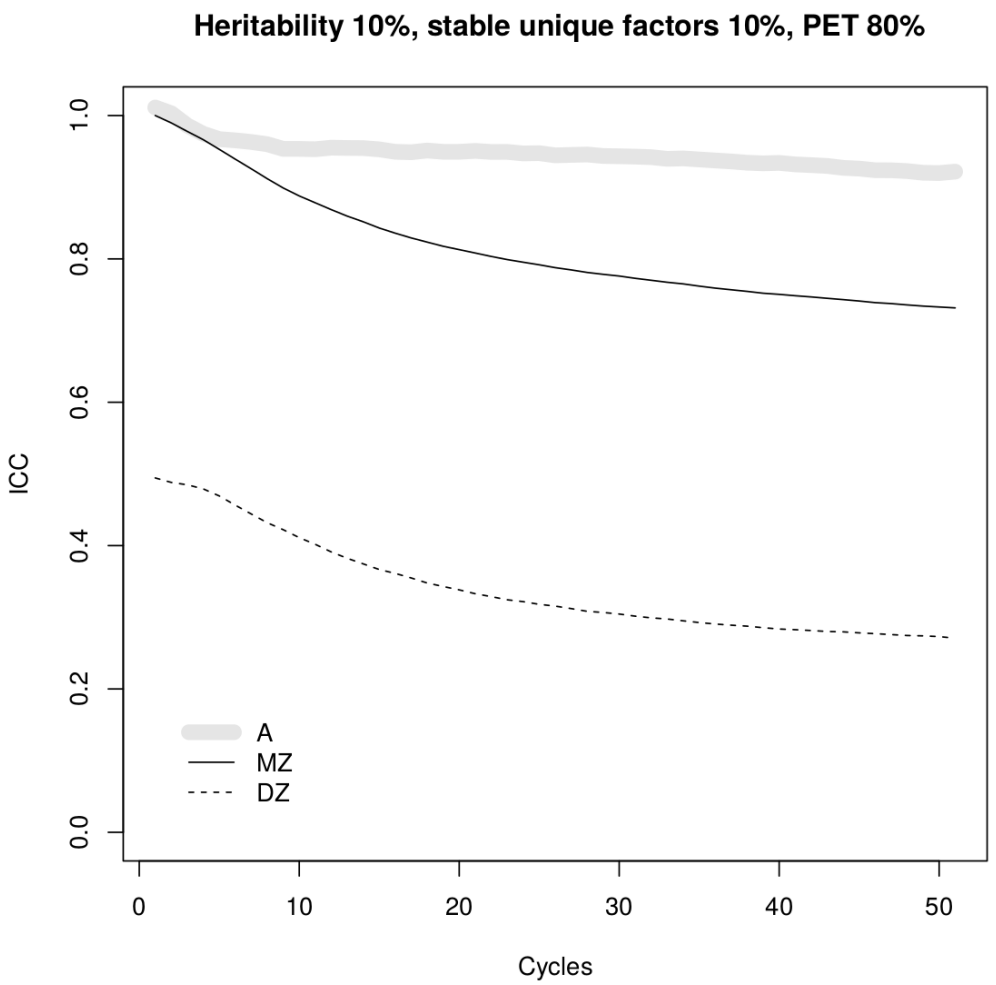

Heritability 10%, stable unique factors 90%
ICC
1.0
0.8
0.6
0.4
0.2
0.0
A
MZ
DZ
0
10
20
30
40
50
Cycles



- Transient random influences not enough to weed out initial strong genetic influences

  - Individuals wiggle into largely genetic niches


Heritability 10%, stable unique factors 10%, PET 80%
ICC
1.0
0.8
0.6
0.4
0.2
0.0
A
MZ
DZ
0
10
20
30
40
50
Cycles


Heritability 10%, stable unique factors 10%, PET 80%
ICC
Cycles
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MZ
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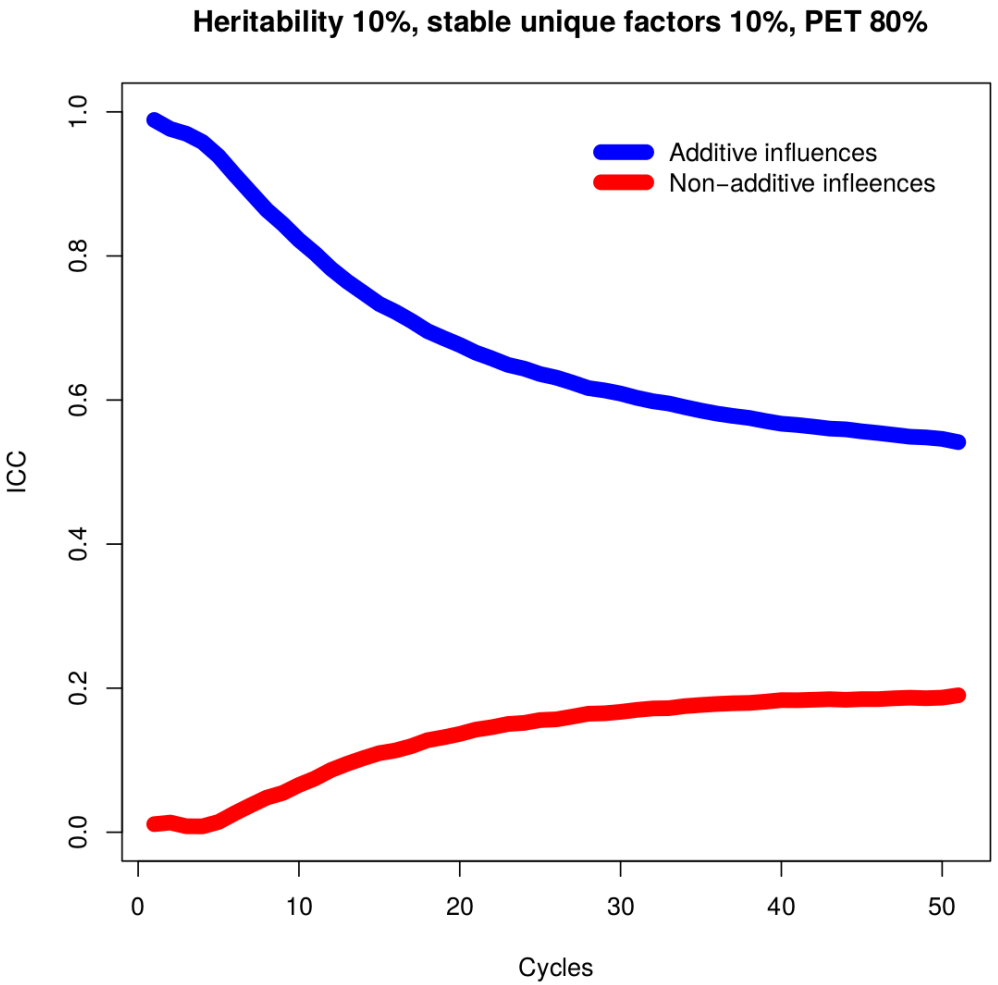
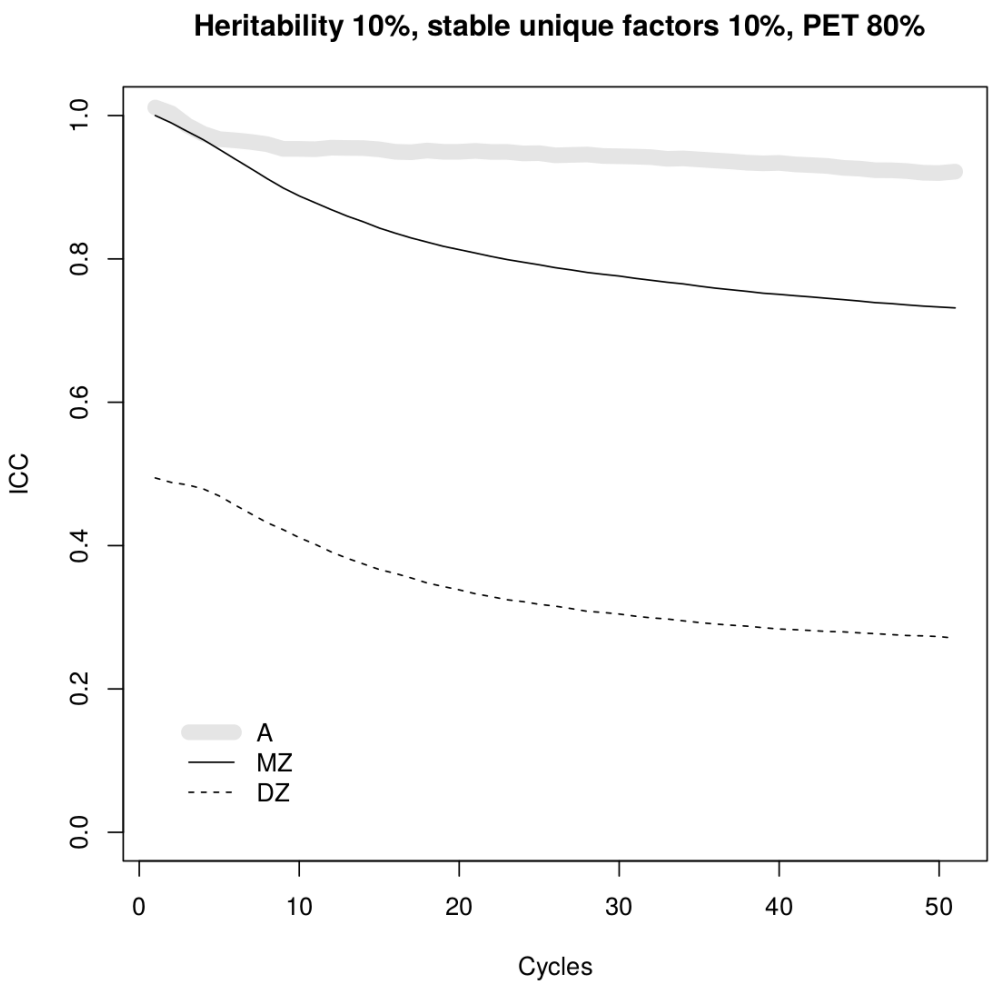
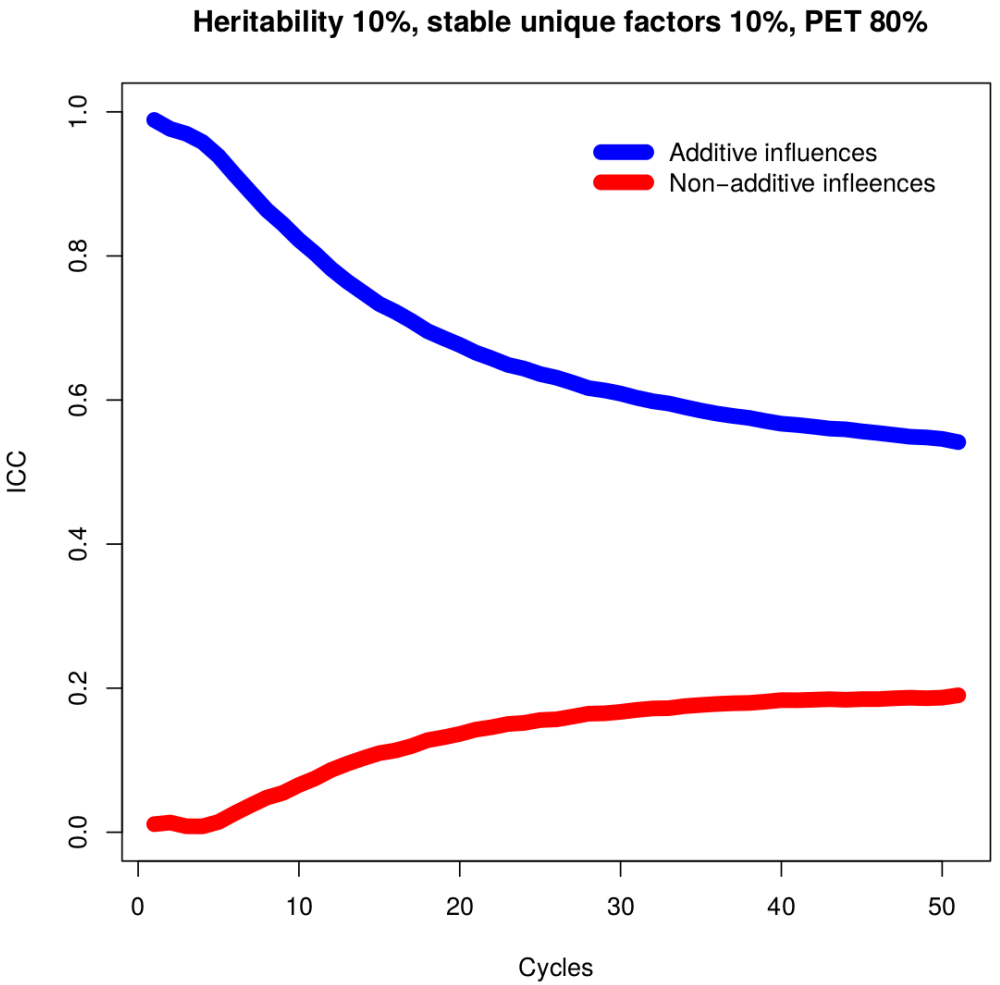
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50

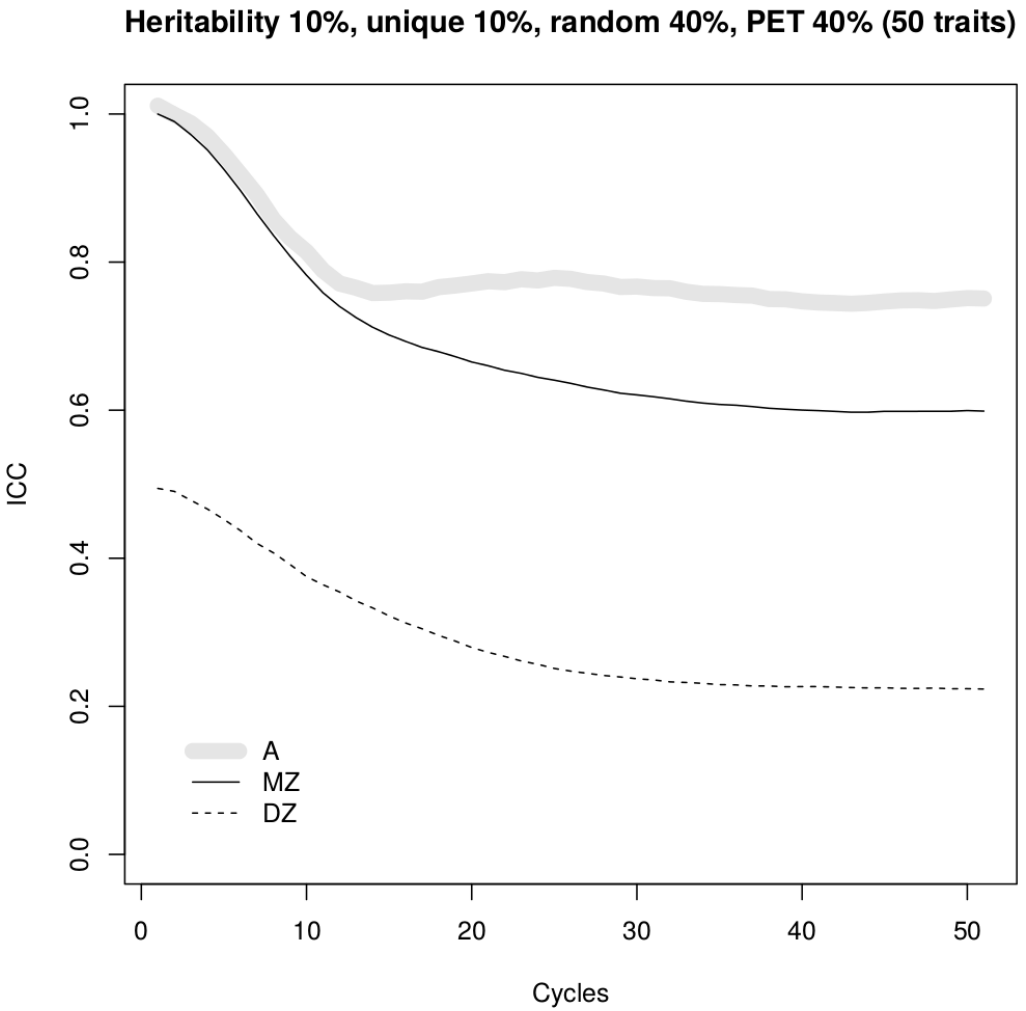

Heritability 10%, stable unique factors 10%, PET 80%
ICC
Cycles
Additive influences
Non−additive infleences
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50

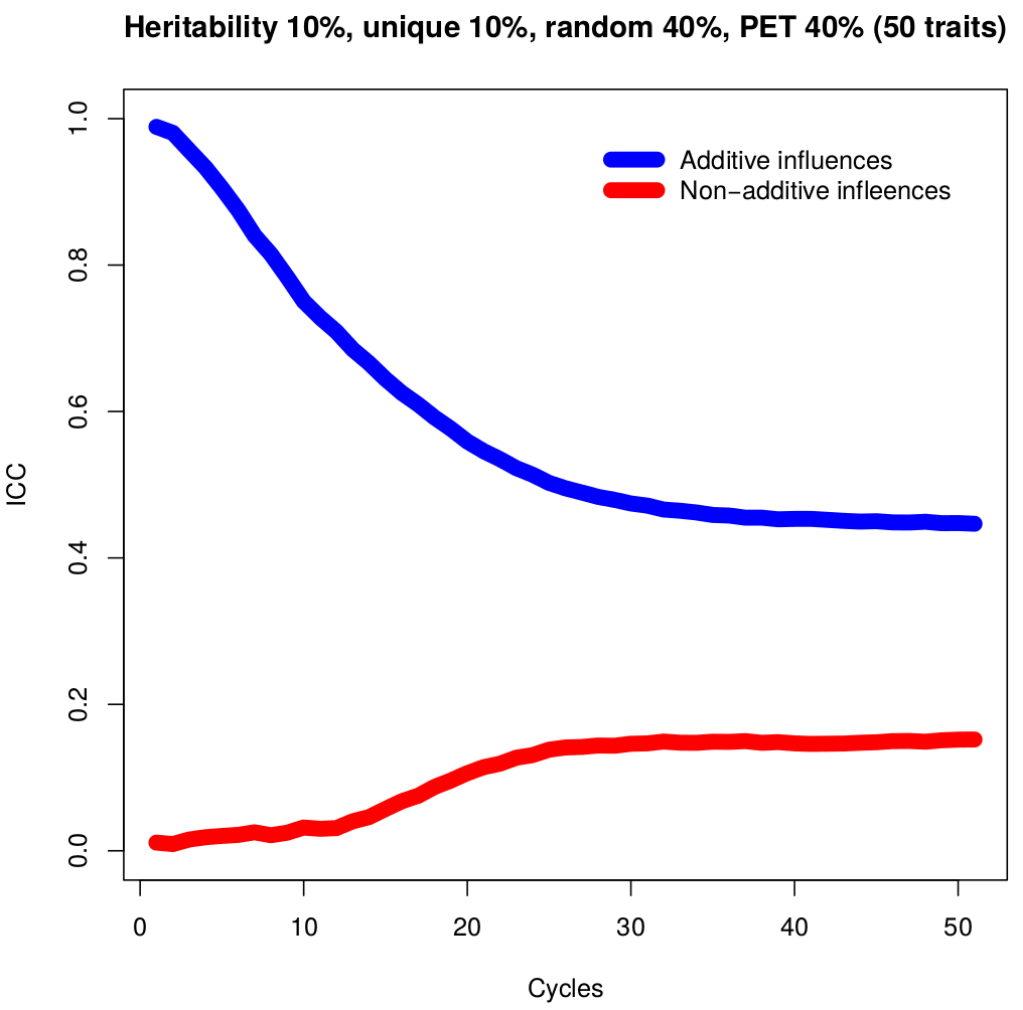




PET based on 25 most expressed traits

PET based on all traits


Heritability 10%, unique 10%, random 40%, PET 40% (50 traits)
ICC
Cycles
A
MZ
DZ
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50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0.4
0.6
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10
20
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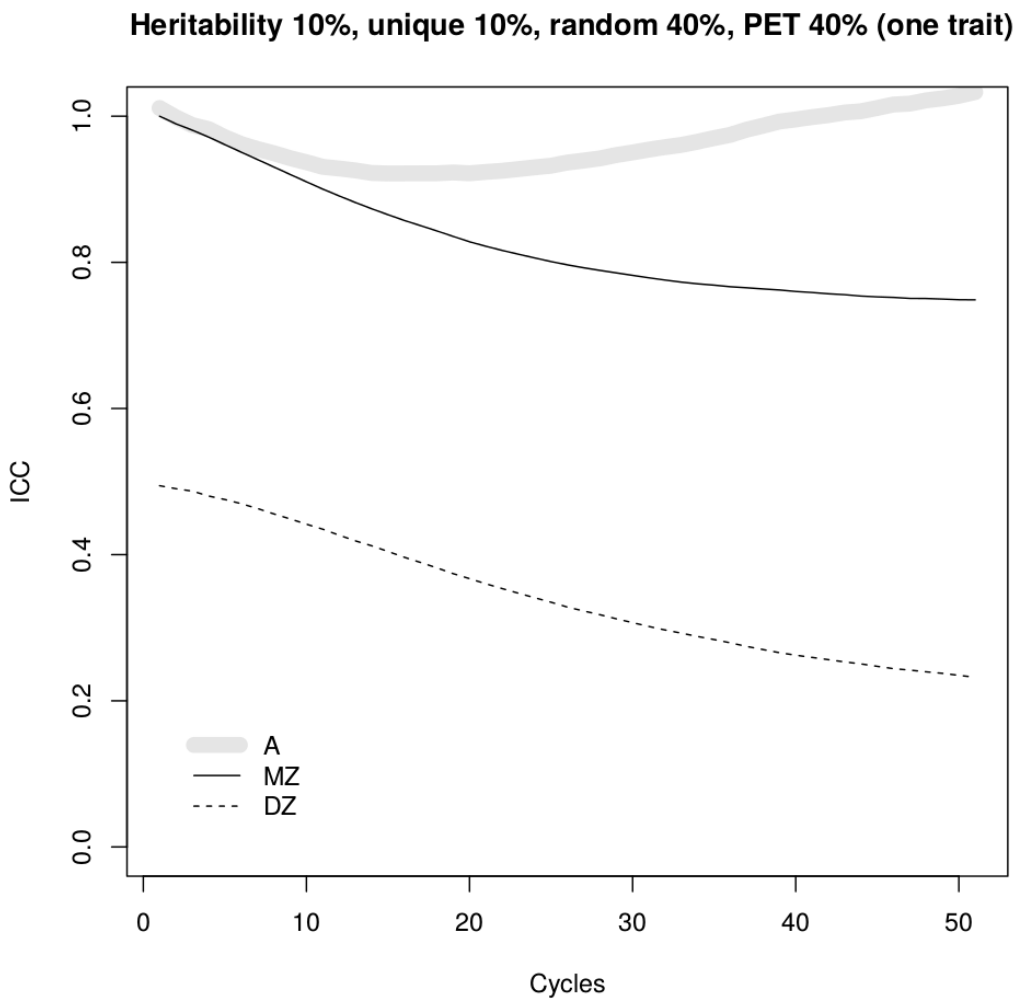
50

PET based on one trait

(the strongest absolute value)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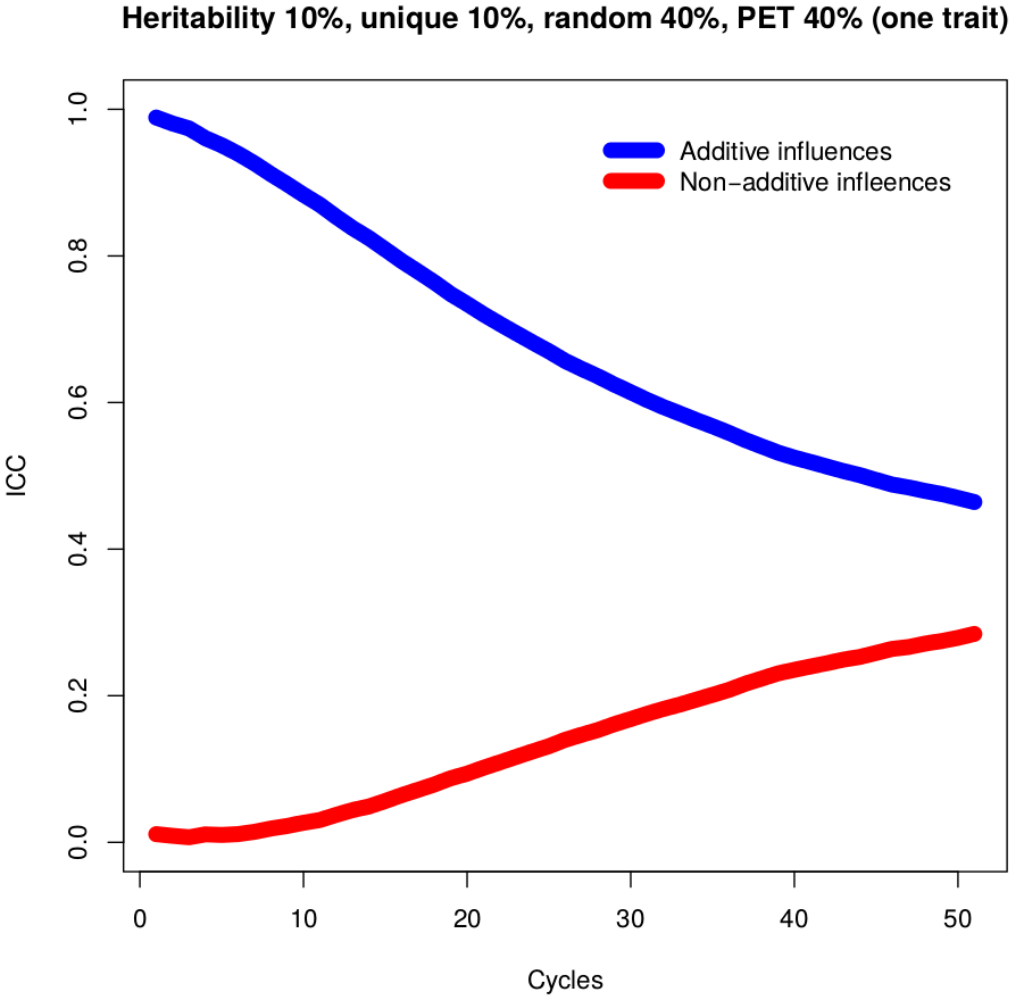
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Cycles
Additive influences
Non-additive infleences
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
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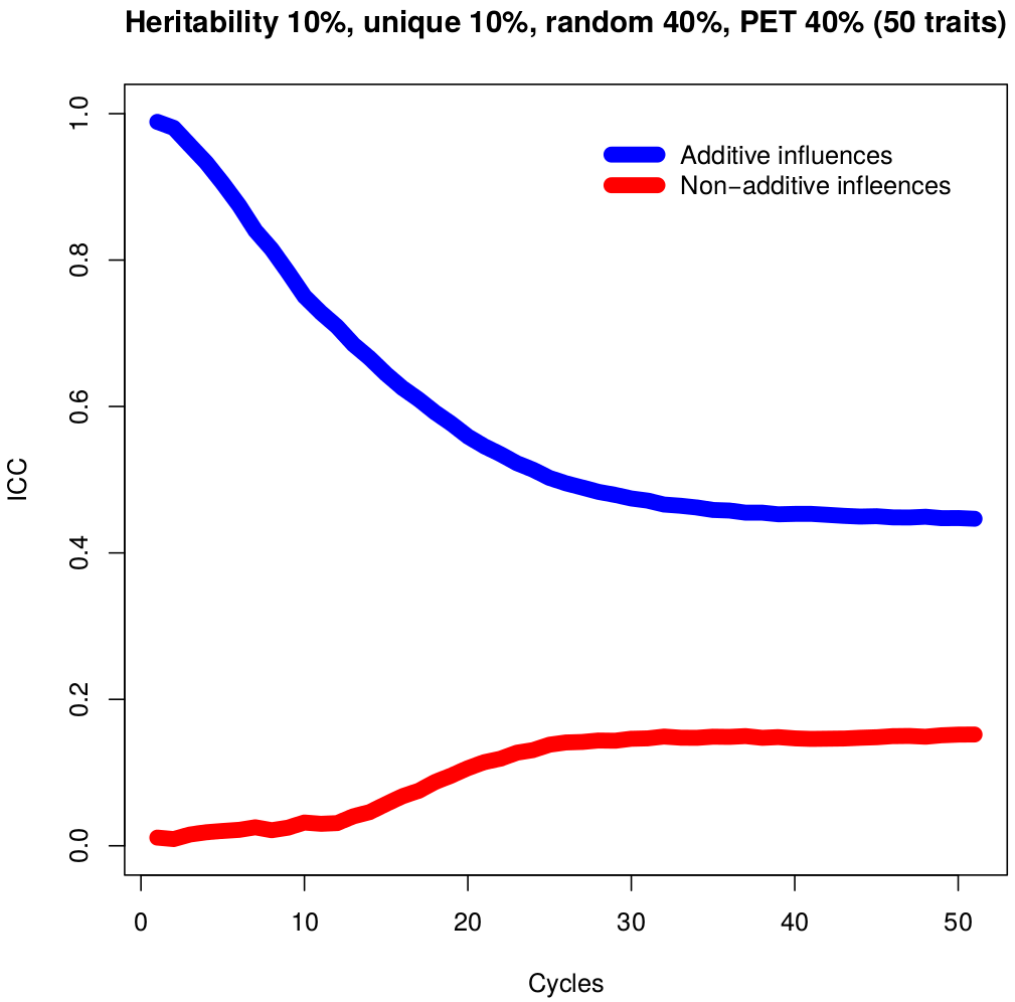
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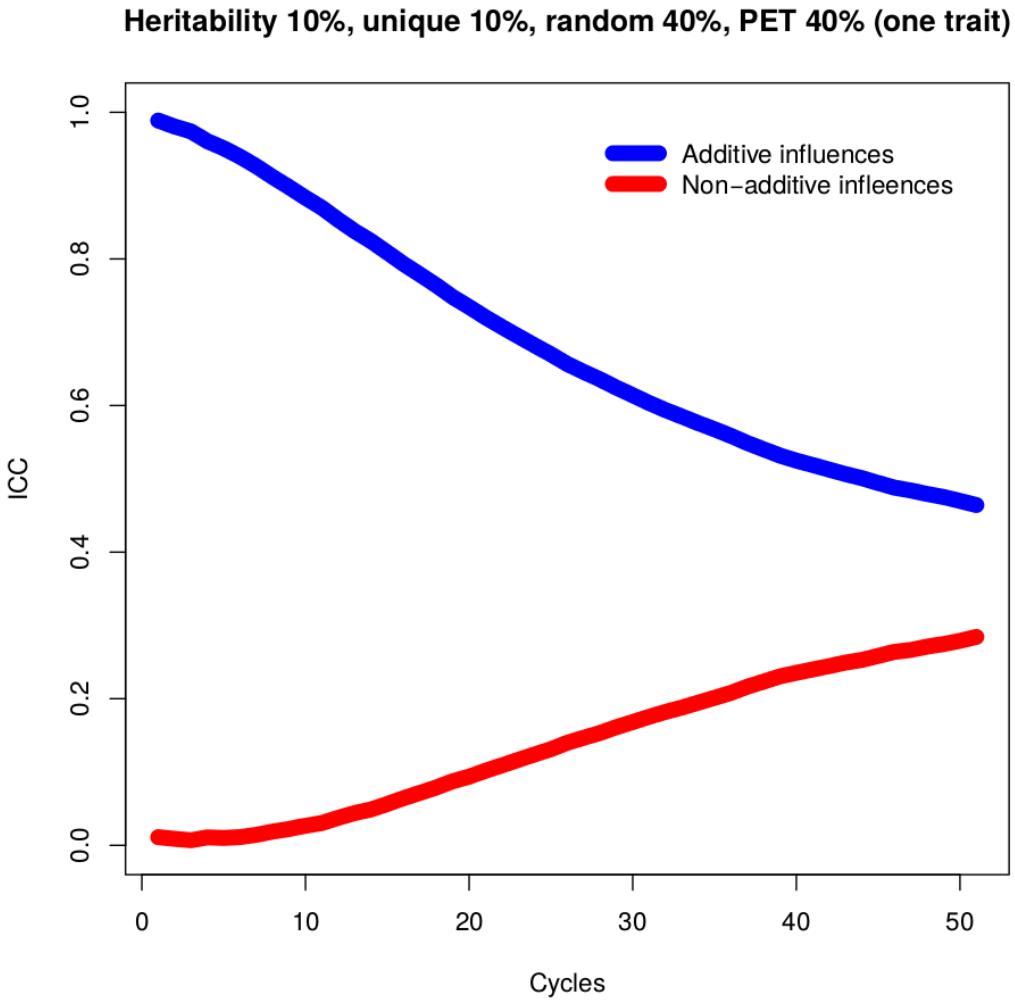
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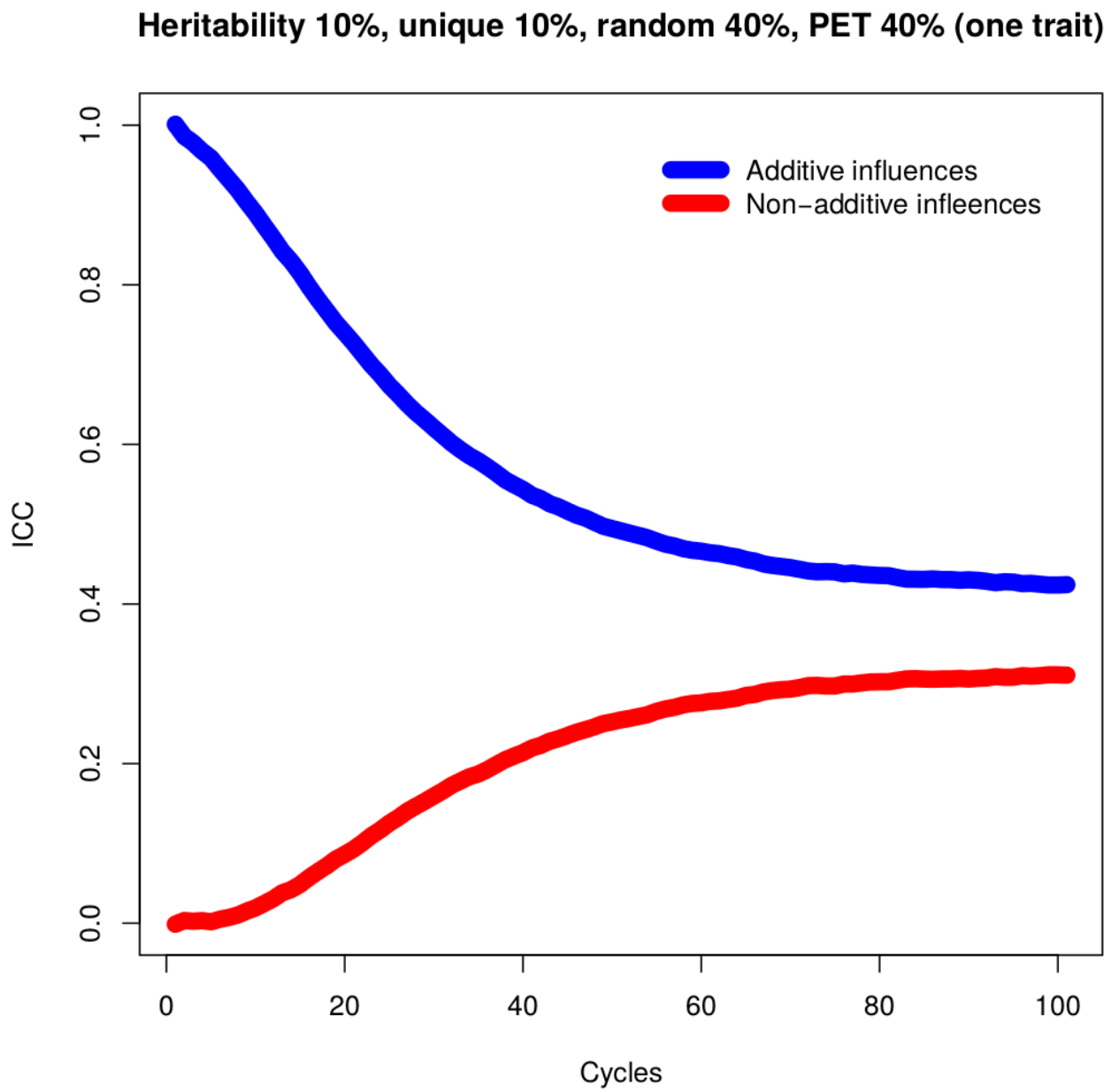
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Non−additive infleences
ICC
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Cycles

PET can inflate heritability

- No news there
- But genetically similar people may become exponentially more similar
  - Especially when PET are idiosyncratic
  - 'Non-additive' genetic influence
  - No interactions between genetic variants involved

Computational models

- **Do not constitute evidence**
- But can be useful thinking tools
  - Play through ideas
  - Proof-of-principle testing
  - Can lead to testable hypotheses
- Implications for variance and 'factors'

Thanks to Mike Allerhand

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